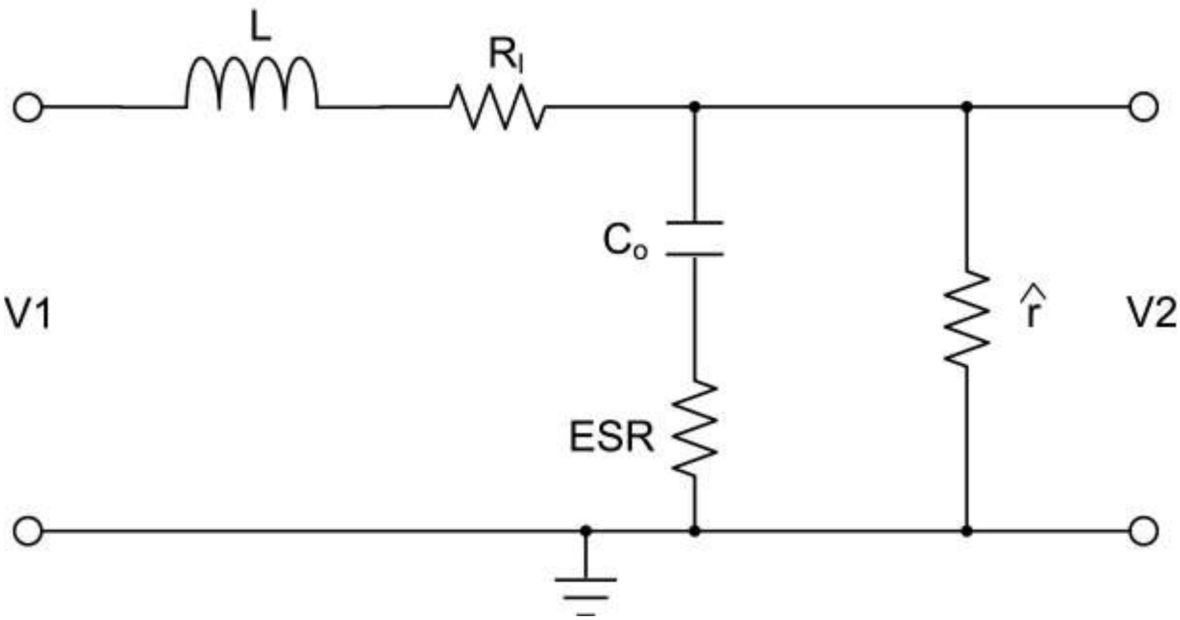
COMPLETE BUCK POWER STAGE

$\hat{d}$	Small signal duty cycle input from error modulator
$\hat{r}$	Small signal resistance of load (Ohms)
C_o	Output capacitor (F)
D'	1-D; applied to commutating switch or diode
D	Duty cycle of active switch
ESR_o	ESR of output capacitor (Ohms)
F_{esr}	Frequency of zero formed by output capacitor(s) and ESR_o. (Hz)
F_o	Effective resonant frequency of power stage (Hz)
F_{rhp}	Frequency of right-half-plane zero (Hz)
F_s	Switching frequency (Hz)
G_{vd}	Control to output small signal transfer function. From output of modulator to output voltage (V)
$G_{vd}(0)$	G_{vd} at zero frequency
I_o	Load current for constant current load (A)
J	Current parameter of small signal model (A)
L	Power inductor value (H)
L_e	Effective power stage inductance (H)
Q	Effective Q of power stage
R_a	Resistance of active switch (Ohms)

R_c	Resistance of commutating switch or commutating diode (Ohms)
R_l	Inductor resistance (Ohms)
R_x	Effective power stage parasitic resistance (Ohms)
V_{in}	Input voltage (V)
V_o	Output voltage (V)

NOTES:

1. The small signal load resistance, $\hat{r}$ is equal to V_o/I_o only when the load is a pure resistance. For a constant current load, $\hat{r}$ is equal to the small signal output resistance of the load current source/sink.
2. This model includes all relevant resistive parasitics.
3. G(s) = V2/V1


L
Rl
Co
V1
r̂
V2
ESR

$$G(s)=\left(\frac{\hat{r}}{\hat{r}+R_l}\right)\cdot\frac{(ESR\cdot C_o\cdot s+1)}{s^2\cdot\left[L\cdot C_o\cdot\left(\frac{\hat{r}+ESR}{\hat{r}+R_l}\right)\right]+s\cdot\left[\left(\frac{\hat{r}\cdot ESR}{\hat{r}+R_l}+\frac{R_l\cdot(ESR+\hat{r})}{\hat{r}+R_l}\right)\cdot C_o+\frac{L}{(\hat{r}+R_l)}\right]+1}$$

$$\omega_o=\frac{1}{\sqrt{L\cdot C_o\cdot\left(\frac{\hat{r}+ESR}{\hat{r}+R_l}\right)}}$$

$$Q=\frac{1}{\left[\left(\frac{\hat{r}\cdot ESR}{\hat{r}+R_l}+\frac{R_l\cdot(ESR+\hat{r})}{\hat{r}+R_l}\right)\cdot C_o+\frac{L}{(\hat{r}+R_l)}\right]\cdot\omega_o}$$

For ESR << $\hat{r}$

$$G(s) = \left(\frac{\hat{r}}{\hat{r}+R_l}\right) \cdot \frac{(ESR \cdot C_o \cdot s + 1)}{s^2 \cdot \left[L \cdot C_o \cdot \left(\frac{\hat{r}}{\hat{r}+R_l}\right)\right] + s \cdot \left[\left(\frac{\hat{r}}{\hat{r}+R_l}\right) \cdot (ESR + R_l) \cdot C_o + \frac{L}{(\hat{r}+R_l)}\right] + 1}$$

$$\omega_o = \frac{1}{\sqrt{L \cdot C_o \cdot \left(\frac{\hat{r}}{\hat{r}+R_l}\right)}}$$

$$Q = \frac{1}{\left[\left(\frac{\hat{r}}{\hat{r}+R_l}\right) \cdot (ESR + R_l) \cdot C_o + \frac{L}{(\hat{r}+R_l)}\right] \cdot \omega_o}$$

For $R_l << \hat{r}$

$$G(s) = \frac{(ESR \cdot C_o \cdot s + 1)}{s^2 \cdot [L \cdot C_o] + s \cdot \left[(ESR + R_l) \cdot C_o + \frac{L}{\hat{r}}\right] + 1}$$

$$\omega_o = \frac{1}{\sqrt{L \cdot C_o}}$$

$$Q = \frac{1}{\left[(ESR + R_l) \cdot C_o + \frac{L}{\hat{r}}\right] \cdot \omega_o}$$